Invited Speakers Executive Panel

Trends and Priorities in Motor Vehicle Safety for the 21st Century

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United States

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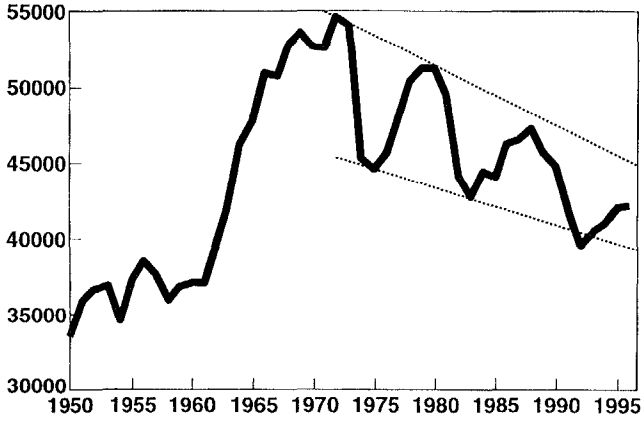
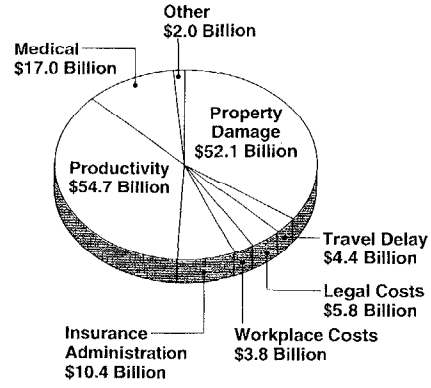
Oral Presentation presented at the Conference.

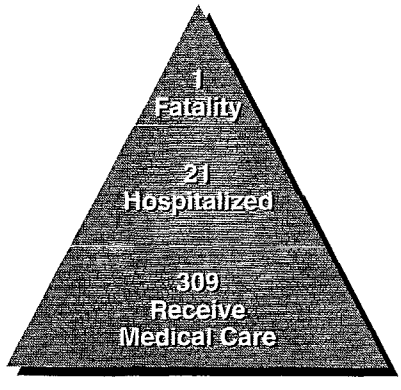
Motor Vehicle Fatalities in the U.S.



Societal Costs of Motor Vehicle Crashes Total $150.5 Billion

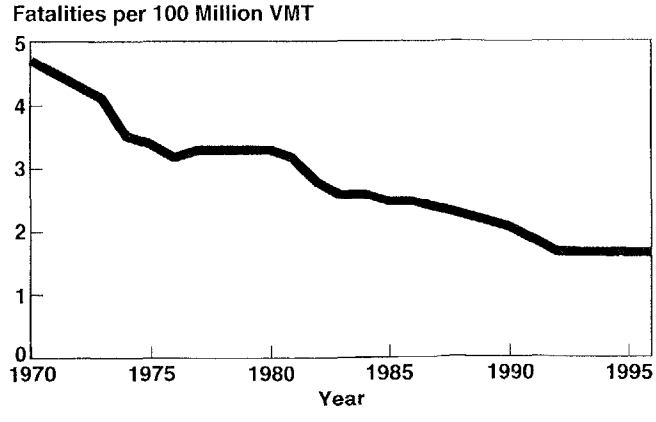


Injury Pyramid

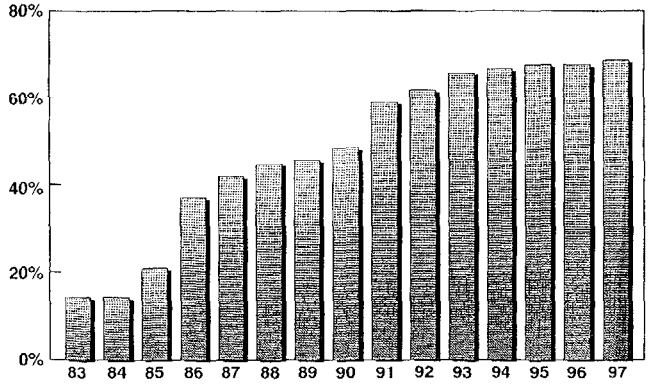


1996, Nat'l Center for Health Statistics

Fatality Rate

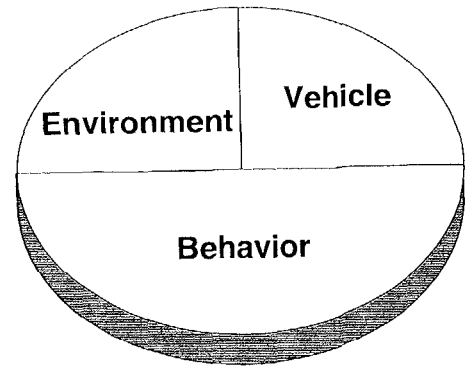


U.S. Seat Belt Use Rates

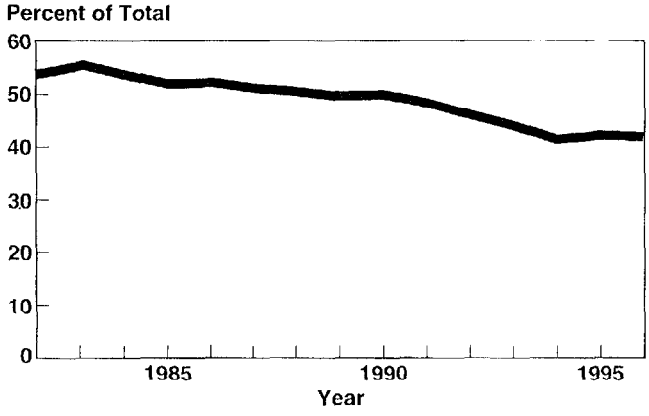


1983-1990 from 19-city survey
1991-1997 from State surveys

Opportunities



Alcohol Related Fatalities



Environmental Priorities

- Rail Crossing Improvements
- Highway Design Upgrades
- Congestion Reduction
- Motor Carrier Safety Improvements

Factors and Challenges

- Diminishing Returns on Vehicle Side
- Harder to Get Returns on Behavioral Side
- Increased Exposure
- More Younger and Older Drivers
- State and Local Enforcement Levels Declining
- Speed Limit Increases
- Aggressive Driving
- Air Bag Risks
- Vehicle Mix Changes
- Additional Distractions
- Globalization of Economy/Emerging Nations
- Need for Emission Improvements/New Technologies

Vehicle Priorities

- Improved Frontal & Side Protection
  - → Improved Restraints
  - → Crash Energy Management
- Improved Rollover Protection
  - → Enhanced Stability
  - → Occupant Protection
- Intelligent Transportation Systems (ITS)
  - → Crash Avoidance
  - → Automatic Collision Notification
- Consumer Information
- New Technologies and Materials
- International Harmonization

Behavioral Priorities

- Occupant Protection
  - → Adult Belt Use
  - → CRS Use
  - → Kids in Back Seat
- Impaired Drivers
  - → .08 BAC
  - → Repeat Offenders
- Enhanced Enforcement
  - → Suspended Licensees
  - → Aggressive Drivers
  - → Automation

Behavioral Priorities

(continued)

- Older and Younger Drivers
  - → Screening
  - → Licensing
  - → Education
- Other Issues
  - → Fatigue
  - → Distractions

Benefits of Harmonized Research and Regulations

- Improved Safety
- Efficiencies of Research/Cost Savings to Governments
- Cost Savings to Consumers

NHTSA Guiding Principles

- Maintain or Improve Safety
- Open Process / Retain Sovereignty

NHTSA Activities – Research

- IHRA
  - → Began in 1996
  - → Identified Five Research Areas
    - Advanced Offset Frontal Crash Protection (EC)
    - Biomechanics (US)
    - Vehicle Compatibility (EC)
    - Pedestrian Safety (Japan)
    - Intelligent Transportation System (Canada)
- Other Area of Cooperative Research
  - → Functional Equivalence (US / Australia)
- Potential Future IHRA Topic – Side Impact Protection

NHTSA Activities – Rulemaking

- Regional (NAFTA, APEC)
- Worldwide (WP.29)
  - → Global Agreement
  - → To Be Open for Signature June 25, 1998

Principal Elements of the Global Agreement

- Open to All UN Members
- Compendium of Candidate Technical Regulations
- Global Registry (Consensus Voting)
- Transparency
- Tiered Harmonization
- Sovereignty Preserved
- Obligations

Challenges to International Harmonization Activities

- Different Safety Environments
- Sovereignty Needs to be Preserved
- Perception of Safety Degradation
- Ensuring an Open and Fair Process

Japan

Kazuyoshi Matsumoto
Ministry of Transport

IN THE 21ST CENTURY

In the 21st Century we will see motor vehicle usage spread throughout the world, with more and more drivers joining the traffic. People will be concerned more about safety, and willingly pay the costs for safety. Governments will be asked to carry out needed regulations, and manufacturers asked to actively improve the safety of vehicles. Crash worthiness will continue as an important issue.

TECHNOLOGICAL TRENDS AND SAFETY

SMART VEHICLES

Smart Vehicles have become popular and we have seen great impact on traffic control, safety, and navigation. In Smart Vehicles the Central Processing Units (CPUs) integrate various sensors and actuators, process data, communicate outside of the vehicle, and determine and control the vehicle.

The **Advanced Vehicle Control and Safety System (AVCSS)** in the U.S. and the **Advanced Safety Vehicle (ASV)** in Japan are similar in the field of automotive technology.

Figure 1. below shows the ASV Road Vehicle Communication/Intervehicle Communication System. These advances are examples of technological trends in the fields of:

I. Preventive Safety
II. Accident Avoidance
III. Autonomous Driving
IV. Damage Mitigation
V. Post-collision Injury Mitigation & Prevention
VI. Fundamental Technology

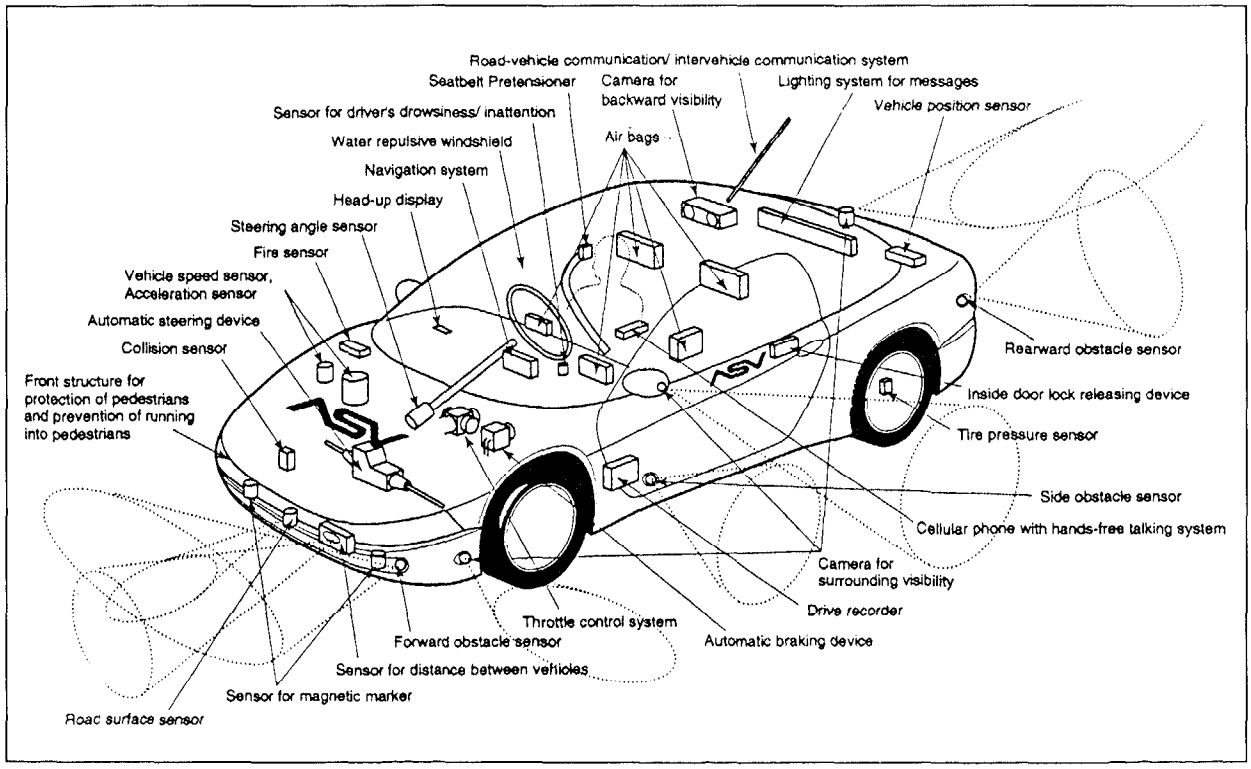


Figure 1. Road -Vehicle Communication/Intervehicle Communication System

An example of a Smart Vehicle component is the **Dynamic Stability Control System**. The System controls the traction force, the braking force and the steering angle, and keeps the vehicle stable depending on the road surface, wheel loads, etc.

The necessary data to control such actions are acquired from within the vehicle, from roadside facilities, or from satellites. The stability control of an automobile with and without the System is demonstrated in Figure 2. below.

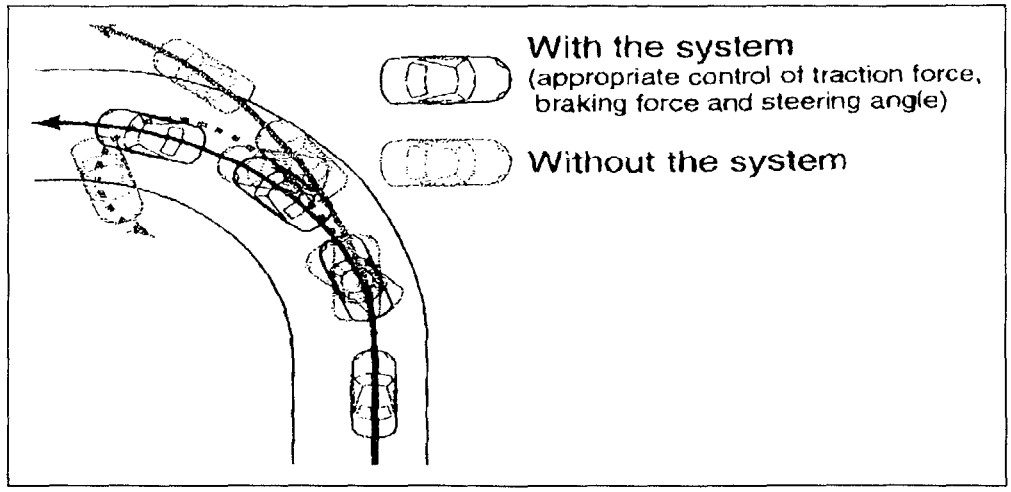


Figure 2. Dynamic Stability Control System

Fail Safe

In failure, the Smart Vehicle becomes a conventional vehicle and the driver may not be able to respond properly. Non-failure is required, and for practical purposes, multiple systems should be equipped. Regulatory authorities will be concerned about to what extent the multiplicity is required for CPUs.

Human Related Factors

With regard to human related factors, the following should be researched and determined:

- Timing and level of system intervention
- Necessity of informing the driver of the intervention
- Method and frequency of information

Out of above the following can be determined:

- What should be regulated and how
- What should be standardized
- What is left to free design

There must be proper understanding of the purpose and limitations of the system.

DRIVE RECORDER

A drive recorder records the data from each sensor and overwrites old data. With the appropriate algorithms to detect abnormal activity, it preserves vehicle data during that activity. The drive recorder makes it possible to obtain accurate reproduction and analysis of accidents, and near misses.

With the Drive Recorder we can determine:

- What sort of movement the vehicle was making
- What sort of action each system was undertaking, and
- What sort of action (operation) the driver was taking

A Drive Recorder can make great contributions to traffic safety, particularly to improving vehicle structure and equipment.

What needs to be resolved:

- How the driver's privacy should be protected
- Who should be charged the extra expense of the recorder
- Who will have access to the data and to what extent

Meanwhile, transport businesses may adopt driver recorders for the sake of fleet control. People may volunteer to have the new technology if certain incentives are provided. In order to facilitate a broad application to safety measures, it is necessary to establish an official framework (law, regulations, etc.) that coordinate matters that need resolution.

GLOBALIZATION

Company to company alliances, and mergers across the borders will result in giant companies with a global reach. Common structure, parts and equipment will be adopted across types and manufacturers. Governments will need to form alliances.

Defects

Common use in large scale of parts, etc., may lead to large scale defects. Safety measures in the marketplace should be reinforced---Governments should work in close cooperation.

Harmonization of Regulations

Alliances should be formed to assure the harmonization of regulations. Existing regulations should be harmonized, and new regulations should be developed under cooperation from the very upstream stages of research.

The UN/ECE/WP29, and International Harmonized Research Activities (IHRA) under the auspices of the International Technical Conference on the Enhanced Safety of Vehicles of (ESV) are the front-runners.

To make the best use of the limited resources in this field, various activities throughout the world should be aligned in cooperation to one main flow.

Note: This paper is a summation of a slide presentation given by Mr. Kazuyoshi Matsumoto. Apologies are offered where summation is not exact.

France

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Renault SA

Priorities in Motor Vehicle Safety for the 21st century

The potential of improvement for safety is still extremely important. The only socially acceptable target is to look for zero killed and severely injured on the roads. A few figures from the French accident research show the potentials. Going from 70 % to 100 % safety belt wear rate could reduce fatalities in cars from one third. In more than half of the deadly accidents alcohol or excessive speed is a direct cause. Those three factors, safety belt, alcohol and speed are directly related to the driver's behaviour and I am convinced that changing the way the driver considers driving is certainly the first source of progress for safety. This has of course a lot to do with political decisions. Nevertheless there are some technological and regulation issues that can also influence the situation for both passive and active safety.

In the area of passive safety, the protection of cars in case of an accident has improved on a significant way over the last 10 years. We can estimate that the front crash protection in a modern car at 60 km/h against a rigid wall is equivalent to that of a car of the late 80s at a speed of 50 km/h. This is due to a very important progress of the restraint systems with the generalisation of belt pretensionners, load limiters and of course the new airbags that are optimised to work in an optimal way with the safety belt. Over the next years the side airbags protecting both the thorax and head will generalise with the same benefits as the frontal airbags. The car to car compatibility is also a very important topic that has to be addressed on short turn.

The next generation of systems will have a lot of adaptation possibilities with multi level airbags or pretensionners, More generally, the protection technology already offers a great potential to adapt the system both to the person to protect and to the crash situation. However, the major issue is to succeed in having reliable tools to identify the occupant and the kind of crash. For instance, the tolerance level of the individual is strongly related to the age. Not having that information available greatly limits the adaptation possibilities of a safety system. Another important issue is the crash severity and how reliable a very early detection of a crash violence can be. The limits of intelligent systems will really be the capacity to feed them with relevant data. We will certainly see the emergence of new links between the active and passive safety systems. As an example, the stability control system of a car can provide information on the pre-crash conditions like the transversal speed in case of a side impact. Other links can of course be done with navigation systems: knowing exactly on which kind of road you are driving can be useful to evaluate the probability of a situation. On another hand, you know how important the rescue time can be. The car is already able to call for help in case of an accident indicating very precisely the location, Renault has already developed a first simple emergency call system. The next generations will give information on the kind of crash, the number of occupants and enable a better tuning of the rescue forces required.

As concerns active safety, there will certainly be a new revolution in the next 10 to 20 years. The next generation of systems will enable you to change completely the behaviour of the car by acting on the engine power, the brakes and the steering system. This can be used on two very different ways. The first way is to take the place of the driver and push the limits of the driving possibilities of the car. This can be very exciting but will be also very dangerous, as because the driver will lose information on the physical limits of the car and once he reaches those limits, he will not be able to control the situation anymore. The second way of using stability controls is to automatically bring back the car into a safe drivability area. This will for instance brake the car when it comes close to the limits instead of correcting the behaviour of the car to be able to go faster. The choice that will be made by the car manufacturers between those two philosophies will have a direct influence on the real world safety and the number of accidents.

Another part of active safety is related to the analysis of the driver's attention and tasks and the crash avoidance measures. In that area also, the short term prospects are worrying. Everybody knows about the statistics of accidents due to the use of mobile phones while driving. All the new communication and navigation systems may turn the attention of the driver from his main activity - driving. Of course, you can imagine very smart and efficient man/machine interfaces but the attention potential of the driver is limited. We have to be very cautious because any task that requires some attention can become dangerous even if you use a vocal interface for instance. A lot of research has to be done in that area to understand where the limits of a dangerous situation are. This is

also a matter of training and may be in 20 years, being able to communicate while driving will be taught before new drivers get their driving license.

Of course, the technology is only one dimension of the safety related problems. The regulation process is a key issue to control and generalise the progress made by the car industry. At the age of globalisation, it is not possible to imagine that the car industry stays with as many local regulations addressing the same safety questions as today. Why should the safety of a car in side impact be tested on two different ways with two different procedures and dummies on both sides of the Atlantic. In that area, the Global parallel Agreement is a very important working frame to develop world-wide regulations. This new regulation process should integrate the best of each regional regulation and promote common testing protocols in all areas. Local adjustments should be done if motivated by accidentological considerations on the existing vehicles, road infrastructure or driving habits. This process is going to take time but Renault, as a global company supports it. The only important thing to preserve is the necessary reactivity in order to adapt regulation to the technological progress. We have in Europe a specific procedure 8.2.c of the 'Reception Directive of vehicles 70/156/CEE' that enables a country to propose some derogation for a new device improving safety. This derogation is going under the condition of a corresponding further regulation change. This kind of procedure was used recently after a Renault initiative to introduce a new generation of safety belts designed to work with an airbag and reducing strongly the risk of thoracic inuries. This new system did not comply with one of the regulations on safety belts. Nevertheless, we could introduce it by demonstrating its efficiency and proposing an alternative evaluation procedure.

I would like to conclude by insisting also on the importance of the political decisions. The car industry is highly competitve and the manufacturers have to offer what the clients expect. It is very difficult for a company to restrict the freedom of the driver from its own initiative. I said in my introduction that the most efficient safety measure would be to reach a 100% seat belt rate. It is very easy to equip the cars with a system that won't start the engine unless the safety belt is fastened. That kind of measure can only be taken by the political power. It has to do with the vision of society, maybe in some cases it should even be decided on a democratic way. The car industry has an important role to play by proposing new solutions to improve safety. The research on accident causes with a very global view is absolutely fundamental. We need to have a thorough understanding of what happened on a large statistical scale to be able to evaluate the efficiency of new devices. An accident is most often a coincidence between a lot of factors. There is not one unique cause but several causes involving man, the vehicle and the infrastructure. In some cases like the pedestrian protection, the most efficient means to progress is probable to invest in the infrastructure and prevention rather than changing completely the design of the cars. In any case, the best possible cost / advantage ratio and the delay needed to see the positive effects of a measure should always be considered by the political power to make the right choices.

United States

Richard L. Klimisch, Ph.D.
American Automobile Manufacturers Association

Overall Trends and Priorities

Figure 1 is a version of the familiar Haddon matrix which indicates that the primary emphasis of traffic safety in recent years has been to improve the crashworthiness of vehicles, i.e. the vehicle-crash cell. It goes without saying that such vehicle improvements will continue but it is widely recognized that the future gains from this approach will be limited. Therefore, the major priority for motor vehicle safety must be to broaden the focus if we are to continue to make significant improvements in motor vehicle safety. There also appears to be general agreement that the top left hand cell, the precrash-driver cell, has the most potential to reduce traffic fatalities and injuries in the near term. Actions included in this cell require changing the behavior of drivers (and passengers). The difficulty of changing behavior, especially long standing behavior, is often underestimated, even when the person knows the behavior is dangerous (smoking for example).

Three behavior change opportunities with the most potential for short term improvements are seat belt use, alcohol/drug use and aggressive driving. We have the most experience with programs aimed at increasing seat belt use rates. The most effective approaches to increase belt use are education and enforcement. Most of us prefer the education approach but such programs have not been able to achieve the desired high levels (90%) of seat belt use. Apparently, only strong enforcement programs can achieve such high levels. One characteristic of these programs is that the occupants whose behavior is easiest to change are those at the least risk and vice versa. That means that the biggest improvements are the hardest to come by and that is why the industry has been so active in programs aimed at passing standard (or primary) enforcement seat belt use laws (now called standard enforcement, i.e. police are able to stop vehicles solely because the occupants are not wearing safety belts). Most states in the U.S. have secondary enforcement programs in which vehicles cannot be stopped unless there is some other violation.

The conclusion is that for a priority ordering based on reducing fatalities and injuries, behavioral changes are more important than technological changes to the vehicle. Based on a variety of sources, it appears that the opportunity for improvements through behavioral change are at least ten times larger than those for vehicle technological changes.

Safety Trade-Offs

Another way to look at priorities relates to which occupants are being protected. This is particularly relevant because it recently became clear that the U.S. approach to regulation of air bags put children and other vulnerable occupants at risk in order to protect occupants who flaunted the law by refusing to wear safety belts. When the reality of this unintended consequence became apparent, the rules were changed quickly. This begs the question as to what the priorities ought to be. An answer to this question and to other related questions is contained in *Attachment 1* which is the "Joint Statement and Recommendations on Advanced Air Bag Technology," put together in March of 1998 by the American Automobile Manufacturers Association, the American International Automotive Manufacturers, the Automotive Occupant Restraints Council and the Insurance Institute for Highway Safety. The priority suggested therein is: "First, priority should be placed on improving protection for belted occupants while reducing the potential for harm to children and other occupants who are out of position. Our goal is to do no incremental harm to out-of-position occupants. Second, priority should be directed to improve protection for unbelted occupants, to the extent consistent with the first priority."

The above issue demonstrates one of the trade-offs inherent with restraint systems. Such trade-offs must always be dealt with. Some suggest that technology will allow us to avoid such trade-offs but that is totally unrealistic. In fact, the vehicle designer is faced with a large number of trade-offs. One that will undoubtedly be inescapable in future is the trade-off between environmental considerations and safety considerations. Great emphasis is being placed on improving fuel economy in future vehicles. For example, the European industry has recently offered to make major improvements in fuel economy in the

coming decade. Similar commitments have been made by the Japanese automotive industry and pressures are expected to increase in the U.S. for additional improvements in fuel efficiency, especially in light of the recent Kyoto Agreement on Global Climate change. These pressures to increase fuel efficiency will almost certainly cause manufacturers to reduce vehicle weight because that is the most direct way to increase vehicle fuel efficiency. It is equally certain that these weight reductions will have an adverse effect on safety as demonstrated by Evans et al. Similarly, it has been estimated that the weight reductions of CAFÉ (Corporate Average Fuel Economy) regulations in the U.S. more than offset the positive safety impacts of air bags. Finding ways to offset the safety deficits of weight reductions will present a significant challenge to the traffic safety community in the years ahead.

Technological Changes

There are many technological changes being introduced into vehicles, e.g., advanced restraints, intelligent vehicle systems, electronic stability control, etc. Regarding intelligent vehicle systems, it would appear that the time is ripe for information but we're not quite ready for intervention. It goes without saying, that such devices also have many tradeoffs including safety tradeoffs.

Because of recent issues about inflation induced injuries by air bags, there has been increased interest in providing sensors that are able to adjust inflation energy or to suppress the air bag altogether if the occupant is out of position or is an infant or vulnerable in some other way. *Attachment 1* discusses regulations and development of such advanced air bag systems. Although we are always looking for a silver bullet, the process will more likely be evolutionary rather than revolutionary. It is also important that the process be driven by data so as to minimize unintended consequences.

Harmonization

Industry is firmly convinced that harmonization benefits everyone and will help optimize safety and environmental systems on a global basis. On the other hand, trade barriers including non-tariff trade barriers lower standards of living for everyone. Clearly, harmonized regulations must be stringent and performance based (as opposed to design-based) and they must be cost effective. It is also crucial that the harmonized regulations be cost effective. If all these conditions are fulfilled then we can be sure that harmonization will indeed improve safety.

Unfortunately, there has been a great deal of negative reaction to the concept of functional equivalency ... and apparently the IIRA activity in this regard has been deactivated. This is unfortunate because it is essential that a methodology be developed for comparing stringency of regulations. It is certain that the first question that will be asked about a proposed harmonized regulation will be: how does it compare to the existing national regulation. It is not realistic to expect regulators to allow stringency to be sacrificed for the sake of harmonization and we must have an accepted methodology to compare stringency.

There are a number of initiatives underway which are directed at harmonization. One of the most important was initiated at the last ESV in Australia, i.e., the International Harmonized Research Activity. It is hoped that this activity will help avoid unharmonized standards in the future. We think it is important to have industry as a full partner with government in the IHRA activities.

WP29 (Working Party 29 of the Inland Transport Committee, Economic Commission of Europe, United Nations) is rapidly becoming the global forum for harmonized standards, especially since the signing of the new Global Agreement (often called the "Parallel Agreement") in Geneva in June of 1998. Actually, WP29 has already developed a number of regulations that approach global harmonization. However, progress has been slow and there are a large number (ca. 100) of existing regulations that have to be harmonized.

Europeanization or Americanization

One of the widespread humorisms is that the U.S. EPA is in favor of harmonization as long as all the other countries adopt U.S. EPA regulations. Similar statements have often been expressed regarding European regulations. Harmonization in this way will give manufacturers in the country whose regulations are adopted an advantage over those in other countries, especially if harmonization results in the predominant adoption of regulations from one jurisdiction. Until the present, the WP29 has been primarily a European forum and the rules developed there have primarily been utilized in Europe; in fact, the forum is currently dominated by European countries in terms of committee chairs, etc. There has been an underlying

concern that harmonization through this forum would simply involve a process in which all countries would adopt European regulations. Since WP29 is part of the Economic Commission of Europe, it is important to do whatever is necessary to give it more of the appearance of the global forum that it has become. For harmonization to be successful, it must not be seen as either a Europeanization or, for that matter, an Americanization of regulations.

Priorities for Harmonization

From an industry point of view, the most important aspects of harmonization are the regulations themselves (including the test procedures). These are more important than the certification or mutual recognition processes which primarily involve the elimination of redundant testing and/or redundant bureaucracy. On the other hand, differences in the regulations would likely require physical modification of vehicle hardware. For regulations like crash standards the modifications could even involve basic structural elements of the vehicle which would likely be prohibitively expensive. Since the new Parallel Agreement seeks to harmonize regulations, it is of great value. On the other hand, after the regulations and test procedures are harmonized industry's next priorities will be certification and mutual recognition as our ultimate aim is to be able to manufacture vehicles that can be "tested once and accepted everywhere."

Compatibility .. *More Than Bumper Height*

There has been a great deal of publicity in recent months about the danger presented by light duty trucks crashing into the sides of small cars. The ratio of fatalities in the truck versus the small car shows that the passengers in small car's are at much greater risk than those in the light trucks for such crashes. Such so-called "compatibility problems" have been with us for a long time. (An even more striking example is the situation in which heavy-duty trucks crash into small cars.) It has been suggested that adjusting bumper height could serve to reduce this incompatibility. Tests presented at this meeting suggest that this approach is erroneous. It should be pointed out that there is both a numerator and a denominator in this ratio. The light trucks clearly provide superior protection for occupants. The side impact tests presented at this meeting by GM indicate that the Mercedes Benz M-Class is not superior with respect to compatibility than cars with higher bumpers and it appears that it is primarily a question of weight which determines the outcome in such crashes.

Summary

There are many ways to consider priorities. Overall, it is clear that the focus on vehicle crashworthiness must be broadened if we are to continue the impressive progress in traffic safety. The area of highest potential appears to involve behavior changes related to seat belt use, alcohol and drug use. In order to achieve the desired results, the approach apparently must involve enforcement as well as education. Technological change will continue, but the largest benefits will come from the aforementioned behavioral changes.

Progress also continues in harmonization, and the IHRA plays an important part in this along with WP29. Major challenges remain to deal with the so-called compatibility problem and the weight reductions that will be required to improve fuel economy. Technological improvements will continue, but we must be constantly aware of the inevitable trade-offs in order to minimize unintended consequences.

Haddon Matrix Showing Historical Focus

	Driver	Vehicle	Environment
Pre-Crash		FOCUS	
Crash			
Post Crash			

Figure 1

AAMA
American Automobile Manufacturers Association

AIAM
Association of International Automobile Manufacturers, Inc.

Automotive Occupant Restraints Council

INSURANCE INSTITUTE FOR HIGHWAY SAFETY

March 1998

Joint Statement and Recommendations on Advanced Air Bag Technology

The following consensus and recommendations on advanced air bag technology were jointly developed by the American Automobile Manufacturers Association (AAMA), the Association of International Automobile Manufacturers (AIAM), the Automotive Occupant Restraints Council (AORC), and the Insurance Institute for Highway Safety (IIHS).

On January 20-21, 1998, representatives of the four organizations listed above and their member companies attended an advanced air bag technology workshop at the IIHS Vehicle Research Center in Ruckersville, Virginia. Air bag system engineers, vehicle design engineers and motor vehicle safety professionals met to review and assess the data relevant to current air bag performance and to discuss advanced air bag technology. The goals of the workshop were not only to review the progress of current and advanced air bag technology but to facilitate the rapid development of future air bag systems and to define consensus policy approaches to best achieve this goal.

As Dr. Ricardo Martinez, Administrator of the National Highway Traffic Safety Administration (NHTSA) said on February 4, 1998, "Seat belts are the single most important life-saving device in a motor vehicle." Air bag systems complement the safety performance of belts and the combination of belts and bags offers the highest level of occupant protection.

SUMMARY OF CONSENSUS AND RECOMMENDATIONS

Occupant restraint systems in use today have been consistently improved and already incorporate a wide variety of technical features designed to reduce the risk of air bag inflation-related injuries, particularly to unrestrained and out-of-position occupants. These features have reduced many of the risks but new technologies are needed to reduce these risks even further. Therefore, the government, vehicle manufacturers, and air bag suppliers have been aggressively working to find additional means to reduce these risks while retaining the lifesaving and injury-reducing benefits that air bags already provide.

AAMA, AIAM, AORC, and IIHS recommend that future government and industry actions:

- **Continue support for educating the public on air bag and seat belt safety and for enacting and enforcing primary seat belt use laws.**
- **Establish priorities for occupant protection.**
- **Assure that future air bag rules are objective, practicable, meet the need for motor vehicle safety and are performance based and data-driven.**
- **Retain the current mid-size male, unbelted, high-speed sled test until other, more appropriate tests for assessing unbelted protection can be developed.**
- **Avoid arbitrary leadtimes and deadlines which may inadvertently inhibit innovation and result in unintended consequences.**
- **Undertake a thorough and timely real-world evaluation of the safety effects of depowering.**
- **Recognize that air bags are just one part of a vehicle's occupant protection system; that no single combination of air bag characteristics is best for all vehicles; and that as a result, attempts to "rate" vehicle performance on selected air bag design characteristics are misleading.**

BACKGROUND

Air bags save lives – more than 2,700 to date – and will save an estimated 3,000 per year when all vehicles on the road have driver and passenger bags, according to NHTSA. Air bags also significantly reduce the risk of serious head injuries. However, out of more than two million air bag deployments to date, deployments in relatively low speed crashes reportedly have caused about 90 fatalities, including 51 children. Of the 39 children aged 1-9 years who died, 31 were totally unrestrained. The other eight (8) appear to not have been in restraints that were properly secured or appropriate for their size and age. There were also 12 fatal injuries to infants riding in rear-facing infant seats that were positioned in the front seat, contrary to warnings against such use. Almost all of these fatalities could have been avoided by proper restraint use and placement. The potential for serious injury from any air bag is greatest at initial deployment as the bag opens the cover and starts to inflate. Properly positioned and restrained occupants are highly unlikely to be within this zone.

CONSENSUS

While technological improvements continue to be important, the most effective way to achieve immediate gains in safety is through increases in occupant restraint use – by having everyone properly restrained and positioned in a seat belt or child safety seat, and, whenever possible, by placing children 12 and under in the rear seat. Efforts must continue to educate the public and to enact and enforce effective legislation at the State level. These behavioral changes will provide the most immediate protection for the occupants of the more than 60 million vehicles with air bags now on the road.

Engineers from government, vehicle manufacturers, and air bag suppliers have been aggressively working, both individually and collectively, to find solutions to help further reduce the risk of serious injury from air bag deployments while retaining the significant benefits that air bags provide. Through their work, air bag technology has evolved substantially over the last 30 years.

A variety of technological features which can help reduce the risk of air bag-related injuries already exists in various combinations in today's air bag systems, based upon the unique design of each vehicle, including some or all of the following:

> low force opening door covers, tethered bags, bag venting location and sizes, aspirated bags, bag tear seam configuration, bag fold patterns and geometry, advanced crash sensor technology, dual deployment thresholds based on safety belt use, recessed modules, child restraint identification for air bag suppression, and the reduction of inflator energy levels – the so-called "depowering" of air bags.

New designs in belt restraint systems are also available to work in conjunction with air bags and are being implemented as appropriate. These include:

> belt pre-tensioners, load-limiters, advanced technology buckle switches, and variable load limiting retractors.

Most of these evolutionary technological improvements have been produced by suppliers and vehicle manufacturers absent any regulatory or legislative mandate. However, depowering required changes in federally-mandated test requirements to permit installation of the lower energy bags. This change came after a consensus statement by the technical community, similar to this document, after a meeting in Toronto, Canada, in November 1996 and an auto industry petition to NHTSA earlier that year. Following NHTSA's regulatory amendment in 1997, the technology was rapidly implemented – it is in most 1998 model year vehicles.

Cooperative efforts by government and the private sector have greatly increased public awareness of the facts associated with air bags and their proper use. Optimum air bag effectiveness is contingent upon proper restraint use and correct occupant positioning.

Further advanced technologies are being evaluated voluntarily and vigorously by automakers and the supplier industry in this highly competitive field. These include:

- crash sensor technology improvements to better predict the severity of the crash;
- occupant location sensors to detect the proximity of an occupant to the air bag module;
- occupant weight sensors; and
- new inflator technology that can vary inflator output, or new sensor technology that can suppress air bag deployment, depending on crash severity and/or occupant characteristics, such as belt use and occupant size and location.

Application of certain of these new and more complex technologies is expected to begin to be phased into selected passenger vehicles in the 1998 calendar year without a legislative or regulatory mandate.

It is important to note that the air bag system – with its sensors, inflators, bag designs and locations, and all the variations associated with those characteristics – is only one part of a vehicle's occupant protection system. Air bag systems must be uniquely configured to a vehicle's crash structural performance, interior design, and belt system. There is no single combination of these features that is "correct" for all vehicles. A combination of features that works well in one vehicle will not necessarily perform as well in another. Differing approaches are needed, depending on variables such as vehicle size, structural stiffness, steering column and instrument panel performance, type of belt, etc. Moreover, there can be more than one "correct" approach for a given vehicle.

And finally, to most effectively attain the benefits associated with air bags requires not only technology changes to vehicles but also changes to occupant behavior, especially having everyone properly belted and placing children in the rear seat. Efforts to educate the public, and enact and enforce effective legislation at the State level, must continue. While there is no opposition in principle to additional air bag regulation – some members of the technical community have already petitioned for this – such regulation needs to be carefully constructed so as not to stifle innovation or require technologies that still may have reliability concerns or unintended consequences.

RECOMMENDATIONS

To achieve this, AAMA, AIAM, AORC, and IIHS recommend that:

- **Efforts must continue to educate the public on air bag and seat belt safety and to enact and enforce primary belt use laws.** Behavioral changes, including increasing seat belt use and securing children 12 and under in the rear seat, whenever possible, are essential to the effectiveness of air bag systems, regardless of which technologies are used. AAMA, AIAM, AORC, and IIHS will continue their efforts to achieve the Administration's goals in this area.

- **Priorities be established for occupant protection improvements.** Safety improvements, from brakes to air bags, never can maximize protection for all occupants in all situations and thus involve tradeoffs. To facilitate the design of advanced air bag technologies, we suggest the following regulatory priorities for improvement of occupant protection be established: First, priority should be placed on improving protection for belted occupants while reducing the potential for harm to children and other occupants who are out of position. Our goal is to do no incremental harm to out-of-position occupants. Second, priority should be directed to improve

protection for unbelted occupants, to the extent consistent with the first priority. In no case should protection be diminished to any group as a result of rulemaking changes. Test protocols need to be developed which reflect these priorities.

- **Rulemaking on advanced air bag technology should be practicable, objective, meet the need for motor vehicle safety, and be performance-oriented and data driven.** Different emerging technologies will be appropriate for different vehicles. No promising approach should be precluded by technology-specific rules or rules not based on performance requirements derived from actual crash and laboratory data. Performance tests, new dummies, and associated injury criteria needed to measure the performance of advanced technology should be developed rapidly and jointly by industry and government.

- **The 30 mph mid-sized male, unbelted barrier test has resulted in less than optimum safety for unbelted occupants and, therefore, should not be automatically reinstated.** Data have shown that this test led to unnecessarily high air bag inflator energy levels. As a result, the sled test was allowed as an alternative to the unbelted barrier test, and this facilitated depowering. Changes in regulatory requirements, including elimination of the sled test alternative and a return to the barrier test, should only be made as a result of the rulemaking process described above.

- **Legislation specifying leadtimes, or other aspects, of advanced air bag technology is not necessary.** We believe market forces and the regulatory process are leading to introductions of phased advanced air bag technology that are designed to reduce the risk of air bag-related injuries. Rulemaking research must be thorough and rigorous, so as to promote the development of safe, reliable, and effective advanced air bag systems and to avoid unintended consequences. This requires that the process be open and transparent to all interested parties. Defining dates by which advanced technology is required could retard development of some promising technologies which might not be available by those dates. Manufacturers and suppliers have been working aggressively to accelerate the development of promising technologies.

- **NHTSA should make the real-world evaluation of vehicles with depowered air bags one of its highest priorities.** There is concern that the agency has not been able to devote sufficient resources to this issue. NHTSA should reallocate resources or seek the necessary additional funds from Congress to quickly and thoroughly evaluate the real-world performance of depowered air bags.

- **The "rating" of air bags by comparisons of selected design characteristics would be meaningless and misleading.** Air bag systems are only part of a vehicle's total, integrated occupant protection system, and they must be "tuned" to individual vehicles. Attempting to identify selected design attributes – such as whether an air bag is "vertically" or "horizontally" deploying – does not enable any meaningful comparisons of the systems in different vehicles.

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I am pleased to be here and have the opportunity to discuss with you the future of motor vehicle safety. However, trying to predict the future, in my opinion, only is possible after one understands the present situation and, more importantly, how it evolved. Therefore, we need to look at the answers to a few questions before I give you some ideas on future needs with respect to motor vehicle safety:

Why motor vehicle safety has become such an important issue?

What has been done so far to enhance motor vehicle safety?

What are the results of our efforts?

Basically, there are only a few fundamental reasons why motor vehicle safety has become so important:

Of course, one obvious reason is the tremendous success of the automobile itself as the main means to fulfill the basic human need for individual mobility. Especially here in North America, where virtually everyone, from individuals to the entire nation, depends upon the availability of cars and trucks, surely no one can even imagine how our lives would be or how modern society would continue to function without, or even with a reduced availability of, motor vehicles.

The second is the increased prosperity of our society, which changed the pure need for mobility into a demand for safe mobility. Simply said, more and more people do not just want to drive, they increasingly ask for safer vehicles in a safer environment or, in short, for safer transportation. One could explain this with the statement that demand for safety in general increases with higher prosperity.

There is obviously another important effect that worked like a catalyst in contributing to this increased prominence of safety in the minds of the consumers:

The increased availability of consumer information programs about the safety of vehicles. Unlike other features such as comfort, styling, performance, which can be easily assessed by consumers on their own, the passive safety of a car cannot be directly determined and compared with that of another model. People have to rely either on manufacturers information or — what they obviously prefer — on independent crash test information like IIHS evaluations on crashworthiness.

Consequently, safety has become a fundamental requirement for most consumers when they are looking to buy a new car. Accordingly, manufacturers have reacted and continue to react to these requirements.

I am proud to say that it is BMWs philosophy on safety to — when ever possible — act, this means to always offer best possible technology to our customers. There are a number of good examples on that.

Having realized that safety is an important issue, the next main question is:

What has been done so far to enhance motor vehicle safety?

When I say motor vehicle safety it includes the following three areas:

- **The vehicle and its technology**
- **The environment or the road network and traffic control systems** and, of course,
- **All of us, the drivers**

Recognizing the greatest effect on road traffic safety could come from our own driving behavior and the environment, I do not want to address these areas in detail, today. As a representative of a vehicle manufacturer, I would like to use my short time to concentrate on vehicle technology. Let me begin with a short overview about what is already available:

Starting with **Active Safety,** that means technology which helps to avoid accidents, I would say that a big step forward was made in the past 10 to 20 years with **systems for a better vehicle handling** like antilock braking systems, automatic stability control, power steering and so on. In addition, progress was made in **comfort during driving,** an important factor for safer driving, as we all know. Many manufacturers at least offer such new active safety systems as an option, some of them — and BMW is one of these pioneers — have already made them standard equipment. Nevertheless, due to the tremendous progress in electronics, I believe we are far from the end of our possibilities in the Active Safety area. I will address this further, later on.

Regarding **Passive Safety** for passenger cars, extreme progress has been made in the past 10 years especially in the area of **body in white crash performance, friendly interior trim, advanced safety belt systems, airbags for frontal and side impact protection** and, last but not least, **fuel system**

integrity.

The increased use of computer simulation of crash tests resulted in very efficient crash energy management in the body structure to reduce dangerous intrusion into the occupant compartment even in high speed offset crashes like IIHS and EURO NCAP are performing. Excellent examples are the recent test results of cars like the BMW 528i, the Lexus LS400 and, even in the smaller car range, the new VW beetle.

Safety belts were made more effective by adding improvements like seat integration, height adjusters, pretentioners and loadlimiters.

Airbags for frontal protection have become standard in most countries, even without any regulation. And now, manufacturers are working on further improving the performance of these systems by integrating smart airbag technologies.

With more intelligent sensor technology, even side impact protection airbags started to enter the market. Just as an example, the new head protection system and thorax side impact airbag are standard in every BMW car.

This kind of technology may be able to address some of the concerns raised by aggressivity/ compatibility issues.

So, a lot has been done already. Let's move onto:

What was the effect of introducing this new vehicle safety technology? Does it really payoff?

For BMW, I can confirm a very positive effect of our new safety technology because most of it already shows results in our own accident analysis. For example, we have seen a significant reduction in severe and fatal injuries in frontal impacts after the introduction of frontal airbags.

As we expected, even our new side impact head protection system, just introduced in 1997, has proved its superior potential for injury prevention in a few severe side impact accidents.

But these are only anecdotal examples. For a general answer to the benefit question, a short look in the overall accident statistics can provide us some more useful information:

The German Road Traffic Fatalities Statistics show a very positive continuous downward trend since the early 70's. The German safety experts relate this result, besides others, especially to the rather high belt usage rate, which was mainly achieved by the early introduction of mandatory safety belt use laws together with efficient enforcement.

Nevertheless, when we look at the total number of fatalities in US, Europe and Japan in 1996, a total of almost 100,000 lost lives, it gives one clear message to all of us involved in road traffic safety:

We must reverse negative trends wherever they exist and reduce fatalities and severe injuries everywhere.

This brings me back to the core question of the panel:

What are the trends and priorities in motor vehicle safety for the next century?

My first and most important answer is:

All three traffic safety areas — the vehicle, the environment and the driver — must make contributions in a correlated way and

Areas with highest potential should be worked on with highest priority.

As I already stated, it is my strong opinion that the most fatality and injury reduction potential is in the areas of the motor vehicle roadway infrastructure and our own driving behavior.

There are excellent examples in Germany for considerable improvement in accident rates with the introduction of intelligent traffic management systems. Such so called "electronically controlled flexible traffic signs" were set up on the highways around Munich in a cooperative program between BMW and the State of Bavaria. Since the introduction of these systems, a remarkable reduction in total accidents, seriously injured occupants and damage loss has been observed and has caused such systems to be permanently introduced on other highway sections.

Regarding the second area, our own driving behavior, I would like to mention the positive effect of education and, if necessary, legal requirements together with effective enforcement.

In Germany, authorities require a rather long driver education with mandatory training for specific higher risk events like night time autobahn driving before they accept an application for final examination.

In addition, it has been shown, time and time again, that higher safety belt usage rates can only be achieved by strong and efficient enforcement.

My strong plea for improvements in these non-vehicle related areas, of course, does not mean that the motor vehicle manufacturers do not want to further contribute to enhancement of road traffic safety. In fact, I assure you that we will continue researching, developing and introducing improved and new safety technology.

But, there is one clear message from customers that every vehicle manufacturer knows all too well:

These technologies must remain affordable. Therefore, they must be based on sound analyses of real accident scenes, rather than, on politically-driven

and sometimes even different and not globally harmonized regulations of the same issue.

In general, such a divergence in regulations does not have a benefit for our customers, but for sure will make the cars more expensive.

By the way, it is my personal opinion, that in the future, vehicle safety will be driven by competition much faster than regulations will ever be able to do so.

For BMW, I dare to say that we will derive further improvements in principle from existing knowledge and primarily from what we learn from our own and others accident analysis. Our so called HPS or side impact head protection system and the recently introduced safety battery connector are perfect examples for that.

As within the whole safety field, also within our responsibility, the motor vehicle safety, of course we should set priorities.

As already indicated at the beginning, for a further reduction of fatalities and severe injuries, I see more potential in the area of active safety than in passive safety.

It could be qualitatively described as follows:

1. Active safety systems (e.g. brakes, improved tires and steering) were available much earlier than passive safety technology, which entered production cars with first considerations of safety passenger cell and crumble zones as well as safety belts around 1970.

2. Passive safety systems, from BMW's perspective, in the meantime have reached a high level of performance for passenger cars. However, the market is no longer only passenger cars and will continue to proliferate into different segments. This proliferation will require a need to transfer technology to these vehicles and, no doubt, dictate further innovative safety improvements.

3. Active safety systems will still have much more potential in the future for further reduced risk of accidents, especially when they will be able to actively communicate with intelligent road side or satellite infrastructure.

A little more detailed, I see the following development on vehicle safety:

First for **passive safety:**

The future will show a refinement of body design, safety belt and airbag systems as follows:

- We will have to put a higher emphasis on the partner protection issue (compatibility) by a corresponding design of the body in white, the bumpers and the engine packaging
- Safety belt systems will be self-adjusting to the particular occupants and accident severity needs
- Deployable safety systems (airbags) will be redesigned to automatically adjust their performance to the needs of the occupants and the severity of the accident
- We will move from simple control of safety systems to intelligent and even predicting, pre-crash sensors

Regarding the **post accident phase** we will have (and in some cars we already have):

- Automatic activation of post crash safety systems
- Automatic emergency call systems
- Automatic position detection and transfer to rescue
- Automatic data transfer of crash details to rescue

In the area of **active safety:**

There will be in a **first step** a continuous introduction of so called **onboard driver information and assistance systems** like e.g. GPS controlled navigation systems and automatic cruise control systems,

And in a **second step**

As a further improvement so called **interactive systems with road side and satellite intelligence systems** for the same purpose

We all do not know, and I personally doubt, if we will have totally auto-piloted driving in the foreseeable future.

For such a purpose, I would prefer to use, although admittedly not yet existing, a highly comfortable and easy accessible rail road transport.

This ends my perception of the situation and the future of road traffic safety.

The Netherlands

Gerard J.M. Meekel
Ministry of Transport

During this session representatives of governments, manufacturers and manufacturer's organizations from United States, Japan and Europe gave their ideas and opinions on possibilities for improvements in road traffic safety. They referred mainly to:

- technical developments in the car (components, systems);
- changes and improvements in the infrastructure;
- and, last but not least, the influences of the human driver and his behaviour.

TECHNICAL DEVELOPMENTS.

Concerning the technical developments in cars it became clear that such developments are still possible for existing safety items, e.g. improvements to nowadays common three-point safety belts, improvements to airbags with an even better timing of the deployment of airbags in accidents, improvements to the seat and seat positioning, decreasing the mass of a vehicle resulting in smaller forces in accidents.

Besides that, other components are already in existence or under development like airbags in sidewalls or under the steering column (lower leg injuries), all with the purpose to diminish injuries after an accident.

It became clear that such technical developments are performed very often by the manufacturers themselves without legal enforcement.

However, it is my strong opinion that legislative action by governments in introducing technical safety measures has quicker and greater positive effect on the introduction of life saving safety measurers in cars than awaiting manufacturer's new developments. These are introduced in their products, on a volontary basis, more as marketing instruments than safety devices.

Motorvehicle industry is globalizing to a greater extend. Such technical prescriptions for cars, their components and systems should therefore be globalized too and developed and applied on a global scale. To this and the Working Party 29 on the Construction of Vehicles (WP29) within the Economic Commission for Europe (ECE), a subsidiary body within the United Nations is such platform for global harmonization of technical requirements.

Before developing and deciding on those global harmonized technical requirements it is necessary that basic research is done on a global basis too. To this end the IHRA (International Harmonised Research Activities) resulting from ESV-15 in Melbourne, Australia, can contribute in an extremely positive manner. This was understood as such too by the panellists.

Although manufacturers equip their motorvehicles very often with safety improving devices which are not required by legislations it cannot be understand that there is sometimes so much opposition when legislative technical prescriptions are developed which governments consider to have a great positive effect. Legislative enforcement of sound technical prescriptions should prevail volontary manufacturers actions.

It is said too often that the manufacturers have to offer what clients expect.

Manufacturers offer also improvements which in my opinion are more marketing instruments than safety enhancing devices.

Also governmental proposals are sometimes opposed because it is said that they have as consequence an increase of the vehicles mass, which is in conflict with fuel consumption goals or environmental aims. However, very often manufacturers, on a volontary basis, introduce all kind of non safety related comfort items which neutralize the positive effect of massreduction.

Manufacturers should have a more positive attitude to governmental safety enhancing items.

It is clear that because of globalization in the motorvehicle industry the technical requirements are to be harmonized on a global basis which, in the opinion of one of the panellists, will, because of that, result in an improvement of safety.

However, it should be taken into account that harmonization on a global basis can result in safety standards at the lowest common denominator and can

be a barrier to enhancement of motorvehicle safety.

Much attention is paid to protective aspects which are adapted to the individual driver and/or passengers (seating and mirror positions, adaptation of safety belts and airbags to individuals).

The question arises whether these developments are parallel to or instead of general safety aspects like for instance the protection of vulnerable road users (pedestrians or bicyclists) in contact with the front of private cars.

Also great benefit is to be expected with the introduction of front underrun protection for heavy goods vehicles, thus increasing safety on the basis of more general items than with individually adapted aspects.

We are not yet at the 80-20% rule: with the introduction of general and not too expensive safety devices a rather good enhancement of motorvehicle safety can still be attained.

CHANGES IN INFRASTRUCTURE.

The relations between technical developments in cars and infrastructure can be seen in new systems.

Much attention was paid by the panellists to complete new systems e.g. smart vehicles equipped with various sensors and actuators.

Such vehicles diminish the necessary actions by the driver or correct the drivers activities when resulting in unwanted traffic situations.

Such influences on the vehicle's movements can be built-in in the vehicle or transmitted to the vehicle from exterior systems built in the infrastructure alongside the road.

This can be built also inside the pavement when considering AVG-(Automatic Vehicle Guidance) systems.

A lot of projects are under development or already realized on small scales.

It is without any doubt that such systems have their potentials.

However, the solution for the nowadays traffic safety problems will not be attained on a short term bases:

- no sufficient infrastructure will be available and suitable for e.g. A.V.G.
- No sufficient number of vehicles will be on the market in due time and at a reasonable price to fit in such systems.

Research and development on such revolutionary new systems should continue.

However, real practical application and introduction on a large scale as a replacement or even as an alternative to the existing systems in not to be expected within the next 20-25 years.

THE DRIVER AND HIS BEHAVIOR.

Much is said by the panellists about the influence on road safety of the driver and his behaviour.

It cannot be denied that we are confronted too often with the negative aspects of excessive speed, alcohol and non-wearing of safety belts.

Legislation in general is sufficiently effective only on the condition that there is sufficient control and enforcement: no-control results in disobedience.

All panellists were strongly of the opinion that strong enforcement of traffic rules like listed above could remarkably contribute to an enhancement of road traffic safety, whilst technical improvements should continue to be developed.

A good driving behaviour should be preceded by a good education of the driver and could be maintained by a continuous information about and awareness of the consequences of non-obeying the relevant legal prescriptions.

How such improvements should be made is an item for another congress, not being an ESV-Conference (or maybe a next or the next ESV?).

MY CONCLUSIONS.

New technical developments for basically new ideas should be based upon continuous IHRA activities.

Thus this can result in internationally, worldwide harmonized technical prescriptions, while safety standards at the lowest common denominator should strongly be avoided.

Safety improvements on a general basis should have priority above individually adapted safety systems and/or devices.

The "market" should be much less a leading factor in vehicle design or for safety aspects than the "government".

Governmental prescriptions should be more often the impetus to enhance the safety of vehicles: without binding governmental prescriptions the manufacturers do not contribute sufficiently; they relate their

developments for safety aspects much more to the "market".

A closer and more positive attitude between government and industry is needed in order to realize substantial effects on a short term basis.

Research and development for new technical systems like smart vehicles or automated guided vehicles should continue, but these will not be noticably effective within the next 20-25 year.

Driver's behaviour and education is a very important aspect and should be improved intensively.

Control and enforcement in obeying traffic rules should be extended enormously.

Reduction of (fatal) injuries should be the paramount aim of all activities in this field, but one must be honest and realistic: traffic with zero fatalities will never occur.